学校编码：10384　　分类号_____密级 _____

学号：22620061152394　　UDC _____

厦门大学

硕 士 学 位 论 文

雨洪管理的低影响开发策略研究及在厦门岛实施的可行性分析

The Effectiveness and Feasibility Analysis of Low Impact Development Stormwater Management in Xiamen Island

刘 保 莉

指导教师姓名：曹 文 志 教授

专 业 名 称：环 境 科 学

论文提交日期：2009 年 5 月

论文答辩日期：2009 年 6 月

学位授予日期：2009 年 月

答辩委员会主席：陈志彪 教授

评 阅 人：朱木兰 教授

张玉珍 教授级高工

2009 年 6 月

厦门大学学位论文原创性声明

本人呈交的学位论文是本人在导师指导下，独立完成的研究成果。本人在论文写作中参考其他个人或集体已经发表的研究成果，均在文中以适当方式明确标明，并符合法律规范和《厦门大学研究生学术活动规范（试行）》。

另外，该学位论文为（　　）课题（组）的研究成果，获得（　　）课题（组）经费或实验室的资助，在（　　）实验室完成。（请在以上括号内填写课题或课题组负责人或实验室名称，未有此项声明内容的，可以不作特别声明。）

声明人（签名）：

年　　月　　日

厦门大学学位论文著作权使用声明

本人同意厦门大学根据《中华人民共和国学位条例暂行实施办法》等规定保留和使用此学位论文，并向主管部门或其指定机构送交学位论文（包括纸质版和电子版），允许学位论文进入厦门大学图书馆及其数据库被查阅、借阅。本人同意厦门大学将学位论文加入全国博士、硕士学位论文共建单位数据库进行检索，将学位论文的标题和摘要汇编出版，采用影印、缩印或者其它方式合理复制学位论文。

本学位论文属于：

（　　）1.经厦门大学保密委员会审查核定的保密学位论文，于　　年　　月　　日解密，解密后适用上述授权。

（　　）2.不保密，适用上述授权。

（请在以上相应括号内打“√”或填上相应内容。保密学位论文应是已经厦门大学保密委员会审定过的学位论文，未经厦门大学保密委员会审定的学位论文均为公开学位论文。此声明栏不填写的，默认为公开学位论文，均适用上述授权。）

声明人（签名）：

年　　月　　日

摘 要

传统的以末端治理为主的雨洪管理措施已不能满足城市健康发展的需要，城市发展需要具有可持续性的雨洪管理策略。低影响开发雨洪管理(LID)通过模拟场地开发前的水文状况，采用分散、多样、小型、本地化的技术从源头上截流、储存、渗滤以及蒸发雨水，最大程度保护开发改造地区的水文情势，减少负面环境影响。学习借鉴这种新策略，对改善我国城市新区开发和旧城改造的雨水资源利用与管理是十分有意义的。

本研究融合多学科知识，对某处植草砖铺设停车场和某半密集型绿色屋顶的雨洪处理能力进行野外监测，并初步分析了在厦门岛采用 LID 措施能产生的环境效益。主要研究结论如下：

第一，LID 措施对雨洪径流具有一定的截留能力。当降雨强度增加时，植草砖停车场对雨水的滞留能力减弱，并与降雨强度呈负相关性。在降雨强度<3.88 $mm \cdot h^{-1}$ 的情况下，植草砖铺设停车场透水区地表径流出现时间相对非透水区车道径流出现时间平均可滞后 30min 以上。植草砖停车场整体上渗透水产生量极小，流出时间极大的滞后于不透水区与透水区径流出现时间。绿色屋顶在相同条件下，雨水径流出现时间可平均滞后 200min 以上。即使在出现渗透水的情况下，由于渗透性能良好，贮水能力强，渗透水流速缓慢，土壤表层无明显地表径流。绿色屋顶贮水能力与降雨强度有直接关系。降雨强度越大，其贮水能力越低。当降雨强度≤1.5 $mm \cdot h^{-1}$ 时，基本可实现 100%的储水效率。

第二，LID 措施具有较好的处理径流污染物能力。经植草砖停车场处理后的地表径流 pH 值可维持在 7.5-8.0 之间；悬浮物滞留率仅为 13.86%；氨氮、硝氮处理效果良好，其中 NO_3-N 的平均去除率 76.55%， NH_4-N 的处理效果不稳定，平均去除率 39%；对溶解态重金属的处理率由高至低依次为 Zn>Cu>Pb，平均处理率达 60%以上；该停车场使用期长导致污染物累积问题加重，使停车场下层渗透水污染物含量高于对应地表径流污染物含量。整体上，该停车场控制污染物能力良好。绿色屋顶出水水质优良，对周边环境没有不良影响。

第三，LID措施应用可行性。LID各项措施的初期建设成本主要集中在景观

开发与维护上，个别措施甚至可以节约初期建设成本，而且在投入使用后不但具有直接的环境效果，还能间接的实现其他环境效益，如缓解污水管道负荷效益、保护下游受纳水体效益、地下水补给效益、景观效益、地产增值效益、改善生态环境质量效益、减缓城市热岛效应以及减少城市噪光污染等环境效益。厦门岛的环境条件适合应用LID雨洪管理策略。

关键词：低影响开发；雨洪处理；环境效益；

ABSTRACT

Water resource protection at the local level is getting more complicated, largely due to the recognition of non-point source pollution, or polluted runoff, as a major problem. This diffuse form of pollution is derived from contaminants washed off the surface of the land by stormwater runoff, and carried either directly or indirectly into waterways or groundwater. Stormwater runoff will bring more problems as the increase of impervious surface area. Low Impact Development (LID) provides new economically and environmentally sustainable tools for local officials, the private sector and others to better address non-point pollution wet weather flow regulatory challenges for the protection of our receiving waters. Instead of the large investments in complex and costly centralized conveyance and treatment infrastructure, LID allows for the integration of treatment and management measures into urban site features. LID encourages the multifunctional cost-effective use of the urban green space, buildings, landscaping, parking lots, roadways, sidewalks, and various other techniques to detain, filter, treat and reduce runoff. LID is completely different from conventional management strategies. Through LID's new advance technological tools it is possible to have better environmental protection for significantly less cost. The LID idea has been developed to many other ideas like LIUDD in New Zealand, WSUD in Australia, the SUDs in UK, etc. In our study, we have selected a pervious parking lot and an extensive green roof in the campus of Xiamen University as the study area and testing their effectiveness in Xiamen Island.

First, flood control ability. The LID practices can be relative effective in controlling peak discharge rates. Under the condition that the rainfall intensity $<3.88\ mm \cdot h^{-1}$, the time when the direct runoff appears on the grasspave pervious parking lot area can delay up to 30 minutes relative to the impervious area. In general, for the study examined, the rainfall intensity will result a noticeable gain in precipitation retention. The infiltrations in the grasspave pervious area are hardly measurable, and greatly delay up to the time when the runoff appeared in the impervious and pervious area. Hydrologic improvements are smallest for large events and high antecedent water contents. The green roof can delay up to 200 minutes under the same condition. Even when the infiltration appeared, the flow rates of infiltration are very slowly. There no measurable runoff

on the surface of the soil. This means the green roof have a high performance in infiltration and can retention a lot rainfall. When the rainfall intensity increase, the retention ability of green roof decreased. When the rainfall intensity ≤1.5 mm·h-1the green roof has 100% retention of precipitation.

Second, pollution prevention and removal ability. The LID practices can effectively reduce and remove the pollutants from the runoff. The pH of runoff can be maintained between 7.5-8.0 after the pretreatment of the grasspave parking lot; the retention of total suspended solids only be 13.86%; Nitrogen behavior is complex because of the biogeochemical complexity of the nitrogen species. Ammonia capture is somewhat variable, with 39% removal, NO_3-N removal was good, at 76.55%; high concentration reductions (>60%) were found for zinc (Zn), copper (Cu) and lead (Pb); the concentration of pollution in the infiltration are higher than the runoff". In general, this grasspave parking lot has a good pollution control ability. The water quality of runoff from green roof is very good and can hardly influent the environment.

Third, using LID practices are feasible in Xiamen island. In terms of costs, LID techniques can reduce the amount of materials needed for paving roads and driveways and for installing curbs and gutters. But the use of LID techniques might not always result in lower projects costs. The costs might be higher because of the costs of plant material, site preparation, soil amendments, underdrains and connections to municipal stormwater systems, and increased project management. But the benefit of using LID techniques can be: reductions in pollutants, protection of downstream water resources, ground water recharge, reductions in pollutant treatment costs, reductions in the frequency and severity of CSOs, and habitat improvements, increases in real estate value, increased parcel lot yield, increased aesthetic value, and improvement of quality of life by providing open space for recreation. The environment condition of Xiamen Island is suitable for using the LID stormwater management strategies.

Key Words: Low impact development; Stormwater Control; Environmental Effectiveness

目　　录

CONTENTS

表索引